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DEPARTMENT OF COMMERCE
BUREAU OF STANDARDS
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HARDENED COPPER

To meet the frequent demands made upon this Bureau for information on the subject of "Hardened Copper" this circular letter has been prepared.

The so-called "lost art" of hardening copper is no secret from present day metallurgists, and no reward for its discovery has been offered by the government. Rumors to that effect have gotten about, and the Bureau has received many inquiries concerning it, following a newspaper story of the rediscovery of the art by an automobile mechanic and its subsequent sale for a fabulous sum.

There is nothing new or "mysterious" in "hardened copper"; immense quantities are in commercial use and more is being added daily. Any metallurgist today knows how to produce an edged tool of hardened copper as good as any made in prehistoric times, but the knowledge does him no good because of the vast superiority of the steel tools now available. This result, which has formed the goal of many an amateur inventor, can be attained by one of two well known processes, or by a combination of them.

Hardening (or "tempering") may be produced by cold rolling or hammering, cold-drawing, etc. Hard drawn copper wire and cold drawn tubing are examples. To supply the needs of a single industry alone, vast quantities of copper hardened by this means are used after hardening in this way, e.g., hard drawn trolley wire.

The second method of hardening copper is to alloy it with a small amount of another metal (or perhaps more than one metal). Zinc, tin, aluminum, and iron are the common additions. The alloyed metal should no longer be referred to as "copper", but should be named according to the chief alloying constituent, added, i.e., brass, bronze, etc. This name may be further restricted according to other additions made, e.g., zinc-bronze, nickel-brass, etc. Vast quantities of copper hardened in this general way are in commercial use. Many of the samples of "hardened copper" submitted to this Bureau for examination have proved to be alloys of copper with small amounts of one of the elements named above.

One of the favorite methods of "hardening" copper appears to consist of manipulating the melting (perhaps unwittingly on the part of the experimenter) so that the resulting melt is impregnated with oxide. Cuprous oxide is soluble in molten copper and alloys with it in exactly the same sense that metals do. Copper hardened in this way is considerably harder and more brittle than the pure metal is, but is unsuited for most of the purposes for which copper is used.

The term "hardened copper" has been used above in its general sense to refer to copper in which the mechanical properties have been modified in the manner usually understood by the term "hardening", i.e., an increase in toughness, a decrease in ductility, etc. The popular conception of "hardened copper" is that of a metal similar to hardened steel and usually implies the "ability to carry a cutting edge".

Numerous samples of "hardened copper" have been submitted to this Bureau for examination. In many samples examined the metal was impregnated with cuprous oxide, thus indicating that an alloying with oxide had occurred during the melting as described above. The product in this case is considerably harder and more brittle than pure copper and has a peculiar red color. Samples of "hardened copper" submitted by one inventor were analyzed by the Bureau and turned out to be nothing more than aluminum bronze, an alloy well known for many years and having considerable use at present. The attempt had also been made to "stiffen" and harden the material by rolling, but the result was decidedly inferior to what would be considered even fair commercial practice. Several years ago a manufacturer of aluminum bronze distributed a small cold chisel of this material as an advertising novelty. This chisel would actually cut soft steel, though its edge was soon dulled. It was superior to the bronze and "hardened copper" axes of prehistoric times, and in those days would have constituted a metallurgical advance. Today it is only an interesting toy.

The following determinations of the Brinell hardness upon different forms of copper and of a sample of so-called "hardened" copper submitted to the Bureau are of interest:

Specimen	B.H.N.(500 Kg.load, 10 mm ball)
Hard drawn trolley wire (23/64" diam.)	107
Hot rolled; 1/4" sheet	68
Electrolytic (cathode) copper as deposited	59
"Hardened" copper, as submitted (Sample contained 5.5% zinc)	39

The popular interest in the so-called "lost art" of hardening or "tempering" copper is evidenced by the numerous inquiries on this subject received by this Bureau, together with samples of copper treated by some "secret" process in the endeavor to render the metal similar or equal to steel in many of its properties. The rather numerous patents covering such processes may also be cited as evidence of the interest in this field, the directions given in some of these patents for the treatment of the metal being very suggestive of the methods of working metals used in medieval times. The following may be quoted as typical:

> "Heat the copper to 260° to 315° and subject it while hot to fumes of burnt sugar and animal fat at a temperature below that necessary to form carbon monoxide."

No industrial application appears to have been made of these patented methods for hardening copper.

Relative to the so-called "lost art of hardening and tempering copper or bronze", the following quotation from Wm. Gowland, Journal of the Institute of Metals, Volume VII, No. 1, 1912, page 23, is of interest and importance. Professor Gowland of the Royal School of Mines is an authority upon the subject of the uses of copper in antiquity and its metallurgy:

> "The castings (knives, swords, etc.) generally were hammered at their cutting edges, and it is to this hammering and to it only, that the (increased) hardness of the cutting edges of both copper and bronze weapons is due, and not to any method of tempering. Much has been written about the so-called art of tempering bronze, supposed to have been practiced by the men of the Bronze Age in the manufacture of their weapons; the hardness is also said to be greater than can be given to bronze of the present day. I should like to correct this error, as it can only have arisen owing to its authors never having made any comparative practical tests of the hardness of bronze. Had they done so, they would have found that the ordinary bronze of today can be made as hard as any, in fact harder than most, of prehistoric times, by simple hammering alone."

For a more complete study of copper and its properties, Bureau Circular 73, "Copper", should be consulted. A copy of this paper may be purchased from the Superintendent of Documents, Government Printing Office, Washington, D. C. for 20 cents, stamps not accepted.

The following articles taken from current literature may also be consulted. They show an agreement in opinion of the

merits of "hardened copper" with that of this Bureau stated above. These articles are probably available in any of the larger technical libraries, or may be purchased in photostat form from the Engineering Societies Library, 29 West 39th Street, New York City for a nominal fee.

"Tempered Copper Phantasies", A. Bregman. Metal Industry, Volume 23, July 1926, page 279.

"Open Season for Hardened Copper", Chemical and Metallurgical Engineering, Number 32, October 1925, page 751.

"The Lost Arts", W. E. Henderson. Industrial and Engineering Chemistry News Edition, September 20, 1925, page 12.

"The Hardened Copper Myth", E. D. Gleason. Metal Industry, Number 22, September 1924, page 352.

"Hardened Copper", Chemical and Metallurgical Engineering, Number 31, 1924, page 215.